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EVALUATION OF A NEW THERMOPLASTIC GUTTA PERCHA OBTURATION TECHN--ETC(U)
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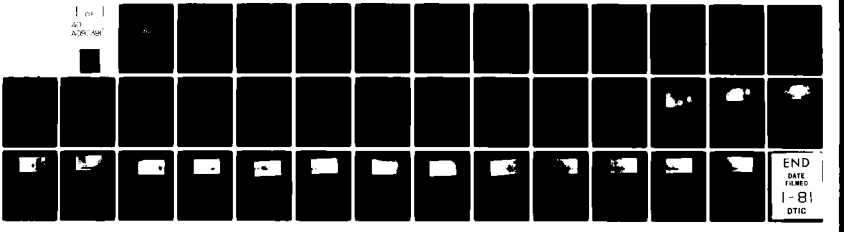

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This study evaluated the leakage following in vitro gutta percha obturation of 60 root canals using 3 techniques, both with and without use of sealer. The techniques were: lateral condensation; warm (vertical) condensation; and the new mechanical compaction (McSpadden) technique. Comparison of the techniques were made by evaluating horizontal sections of the teeth by radioautography after soaking the teeth in ^{45}Ca. The difference between techniques was not statistically significant. Additionally, at only one level (1.4mm) in only one technique (compaction) did sealer show an improvement in seal at a statistical level of even $p<0.085$.

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Since this cannot be considered statistically significant, factors which may have lead to the results are discussed.

EVALUATION OF A NEW THERMOPLASTIC GUTTA PERCHA OBTURATION TECHNIQUE USING ^{45}CA

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ABSTRACT

This study evaluated the leakage following in vitro gutta percha obturation of sixty root canals using three techniques, both with and without use of sealer. The techniques were: lateral condensation; warm (vertical) condensation; and the new mechanical compaction (McSpadden) technique. Comparison of the techniques were made by evaluating horizontal sections of the teeth by radioautography after soaking the teeth in ^{45}Ca. The difference between techniques was not statistically significant. Additionally, at only one level (1.4mm) in only one technique (compaction) did sealer show an improvement in seal at a statistical level of even $p<0.085$. Since this cannot be considered statistically significant, factors which may have lead to the results are discussed.

INTRODUCTION

In the development of endodontic therapy, many types of filling material have been used for obturation.[1-3] Various techniques of obturation have also been employed. In present day endodontic therapy, the most common obturating material in use is gutta percha, combined with some form of lateral or vertical condensation.[4] McSpadden[5] has recently demonstrated a new technique of warm gutta percha obturation of root canals. This technique utilizes a file-like instrument which fits into the slow speed counter-angle handpiece. It is then placed into the canal next to a master gutta percha cone. Upon clockwise rotation of the instrument friction will warm the gutta percha and condense it apically.

Many studies have shown that the development of a fluid-tight seal at the apical foramen is one of the primary objectives of endodontic therapy.[3,6,7] Various radioisotopes have been utilized to evaluate the adequacy of the apical seal.[8-13] One preferred radioisotope is ^{45}Ca because of its polarity, small particle size, ability to rapidly penetrate dentin and its ability to produce a sharp image on X-ray film. Swartz[14] developed an autoradiographic technique to test leakage of coronal restorations. This technique was utilized by Higginbothan[9] to study the apical seal of various root canal sealers. The purpose of this study was to utilize ^{45}Ca to compare the apical seal produced by two commonly used gutta percha obturating techniques, lateral and warm (vertical) versus the seal produced by the warm mechanical (compaction) gutta percha technique.

METHODS AND MATERIALS

Sixty single rooted teeth, placed in a 10% formalin solution immediately after extraction, were utilized. Twenty-four hours prior to preparation they were placed in a 5.25% NaOCl solution to remove any organic debris remaining on the root surface. To eliminate any variability from access preparation, the crowns were removed with a high-speed burr at the cemento-enamel junction prior to instrumentation. Pulp tissue was removed with barbed broaches. The canals were then prepared with K files using a step-back or flared technique as suggested by Coffae and Brilliant,[15] and Walton.[16] Sterile saline was used as the irrigating agent and all canals were patent to at least a #10 file. Following instrumentation, the teeth were divided into 6 groups and treated as follows:

GROUP I - ten teeth obturated with gutta percha via the compaction technique (McSpadden) with no sealer.

GROUP II - ten teeth obturated with gutta percha via the compaction technique with Proco-Sol used as the sealer.

GROUP III - ten teeth obturated with gutta percha and lateral condensation without sealer.

GROUP IV - ten teeth obturated with gutta percha and lateral condensation with Proco-Sol used as the sealer.

GROUP V - ten teeth obturated with gutta percha via vertical condensation (warm gutta percha technique) with no sealer.

GROUP VI - ten teeth obturated with gutta percha via vertical condensation with Proco-Sol used as the sealer.

The attempt was made to have all final instrumentation and obturation 1.0mm from the anatomical foramen (where the size #10 instrument exited the tooth). After final obturation, all teeth were maintained in an environment of 100% humidity for 2 weeks to allow the sealer time to set. An autoradiographic procedure similar to that of Higgenbotham[9] and Brown and others[11] was used to evaluate the apical seal. The root surface of all the teeth was coated with fingernail polish and then covered with tin foil, except for a 2mm area at the apical foramen. The teeth were submerged in phosphate buffered saline which contained 50 microcuries of $^{45}Ca+$ per ml of solution at 37°C for 4 hours. They were then washed under running water for 1 hour, soaked overnight, scrubbed with liquid detergent and a brush to remove any residual radioisotope. The roots were then mounted in dental stone and sectioned horizontally with a saw* equipped with a new diamond blade 0.4mm thick. The initial section was made 1.0mm from the anatomic apex. Subsequent sections were made 1.5mm thick at 2.9mm and 4.8mm. The sections with a periapical radiographic film# on each side were placed between two stainless steel plates (1/16" x 1 3/4" x 1 1/4"). These units, up to nine sections thick, were secured tightly together by rubber bands and wrapped in aluminum foil. They were stored in a light-proof lead container for both 4 and 17 hour periods.

Each radiograph was developed and projected on a screen at 20X for evaluation by three observers working independently, and categorized as leakage or no leakage. The ^{45}Ca produced a sharp outline of the outer exposed root surface. Penetration of ^{45}Ca along the obturating material

+ New England Nuclear, Boston, Massachusetts 02100
* Bonwil TSM 77, San Francisco, California 94119
# Kodak Perioapical Ultra-Speed Film, Eastman Kodak Co., Rochester, NY 14650

resulted in a circular or semi-circular exposure in the center of these outlined areas. If the dark line next to the central core appeared darker than the adjacent background, it was considered leakage. If any investigator rated the specimen as leaking, it was placed in the leakage category. The number of sections from the apex that show ^{45}Ca exposure indicate the coronal extent of the leakage. The experimental data was analyzed using the chi-square test of independence of categorical variables, and the Fisher's exact probability test.

RESULTS

Table 1 shows the number of specimens of each group which exhibitied leakage at the 4 and 17 hour exposure times.

Using the chi-square test, the data from all the specimens was compared at both 4 and 17 hours (Table 2). Results show a larger, but not statistically significant ($p<0.20$), number of specimens designated as leaking in the 17 hour group. This is in agreement with the suggested exposure time as recommended by Swartz.[14] Figure 1 shows a comparison of the 4 and 17 hour exposure times.

The chi-square test showed no significant difference in leakage whether sealer was used or not (Table 3). The Fisher's exact probability test was used to check sealer versus no sealer at each level of sectioning to determine if any statistical difference was present in how close to the apex the seal occurred. The only level that came close to showing statistical significance was the first cut for mechanical compaction (4 of 10 leakage with sealer versus 8 of 10 leakage without sealer, $p<0.085$). The only other levels which gave an appearance of possible significance

were the second cuts of both the lateral and vertical techniques (2 of 10 versus 4 of 10 leakage). They proved to be of no significance ($p<0.314$). Figures 2, 3, and 4 show examples of leakage of various levels for each of the three techniques, with and without sealer.

DISCUSSION

The results dealing with sealer or no sealer were somewhat surprising. Prior to evaluating these findings, some comment on the levels of leakage and our process of determining leakage from the autoradiographs is indicated.

First, in this study a darkening next to any portion of the central obturation material made it a leakage specimen. Occasionally, a dark line went from the outer root surface toward the central area where the obturation material was, but with no spreading around the central material. These likely were cracks or lateral canals and if there was absolutely no spreading present, it was read as no leakage (Fig 2B). In no case where we read a specimen as no leakage did an area more occlusally have leakage. It seems likely that some sections more occlusally would exhibit leakage if the cracks or lateral canal areas were really areas of leakage.

Second, even though our instrumentation and obturation were carried out at a level 1mm from the true apex, it was apparent that the initial cut (made 1mm from the anatomical apex) was not consistently at a level which included gutta percha. In several specimens, only the root apex was sectioned while in others, it was obvious that only the sealer filled or even unfilled apical portion was sectioned (Fig 1A).

Subsequent sections were made at 1.5mm intervals (plus the width of the diamond blade 0.4mm). All sectioning measurements listed are basically from the anatomic apex and not where the canal may exit the root surface. Therefore, these figures are generally at least 1m longer than the true length of obturation.

Third, in this study dental stone was used to mount the teeth prior to sectioning. It was found that dental stone makes sectioning much easier and faster. Neither stone nor acrylic adhered well to the specimens and stone is more fragile. To adjust for these problems, sections were made slightly wider (1.5mm) than normal. In a few cases a generalized background radiation, as shown in Fig 3 C-D, occurred. This was a rare occurrence and did not appear to be a problem in leakage diagnosis for any of the evaluators.

Next, since a much higher level of leakage in the cases without sealer was expected, prior studies not using sealer were checked. Marshall and Massler[12] filled teeth with single gutta percha cones with and without sealer. In the cases without sealer where they placed only the tooth apexes in the radioisotope, they had complete penetration in 75% of the cases. This was true in spite of the fact that no lateral condensation was done. In other words, just placing a single gutta percha cone snugly stopped leakage in 25% of the cases. Kapsimalis and Evans[10] did use lateral condensation without sealer and found what they called gross leakage, but they did not present any specific data on just what this meant. Most other studies showing the gross leakage of gutta percha without sealer are dye and bacterial leakage studies.

In the cases where sealer was used during obturation, the data compared quite well with prior studies. Marshall and Massler[12] using the single cones and sealer reported no cases of total leakage, but up to 75% of the cases showed slight leakage. This 75% would appear to relate well with our 80% leakage 0.4mm beyond instrumentation and obturation, but only 20% leakage at the next level. This seems to relate very closely in spite of their use of vertical sections. With vertical sectioning rather than horizontal, you would expect to see less leakage at any specific level since the slice only includes two small portions of the canal circumference rather than the complete 360^{o} degrees. Higginbotham[9] used ^{45}Ca to evaluate leakage in extracted teeth obturated with lateral condensation and various sealers. While no statistics on leakage were included, he did show leakage of approximately one-third of the lateral condensation fills with sealer. This again appears quite similar to our 20% leakage at the second cut or 2.9mm level.

Cooke et al.[13] prepared teeth using EDTA and sodium hypochlorite and then filled the canals using sealer with gutta percha or silver points. While a great difference in volume of radioisotope penetration could be shown, they were unable to show a difference in depth of penetration. In this study, using lateral condensation, sealer did reduce the leakage at the second cut level from 4 of 10 to 2 of 10. With the compaction technique, the increase in seal occurred even sooner or at the first cut with 8 of 10 without sealer leaking and only 4 of 10 with sealer leaking. In both techniques though, by the next cut

the leakage rate was the same (Table 1). Therefore, for both of these techniques the sealer did appear to make a difference in allowing a seal closer to the apex. In neither case was the difference at a statistical level generally considered significant. However, in the cases of vertical (warm) fills, the results seemed to be reversed or we got better seals closer to the apex without sealer than with sealer.

One basic difference in this study from prior studies was the removal of the crowns for ease and consistency in instrumentation. This allowed excellent access for instrumentation of the canal and did result in a nicely tapered canal which allowed obturation instruments excellent penetration for maximum condensation close to the apex. Weine and others[18] have shown that the type and method of instrumentation has an effect on the shape of the canal and may play a role in effective obturation. Most of the current studies[15-17] have shown that a flare type preparation allows more thorough debridement and complete obturation. Allison and others[17] have shown that a flare preparation which allows spreader usage closer to the apex than a standard type preparation, will result in a better apical seal. This study appears to carry this point one step further with depth of condensation being more important in relation to radioisotope leakage to a level of 4.8mm than the presence of sealers.

Appearing to add substance to this finding that condensation rather than sealer appears to be the more determining factor in whether or not leakage occurs is the recent study by Yates and Hembree.[19] Here they filled the teeth with single cones and various sealers. In spite

of using both vertical sectioning and sealers they still had leakage of one-half the canal length in 30.8% of 120 cases. Compared to studies where lateral condensation was added to the procedure the leakage rate was high,[10,17] while compared to single cone fills without sealer the leakage rate was low.[12] One-half the length of the canal corresponds best with the 4.8mm level in this study where with or without sealer the leakage was 10% of the 60 cases. Again, it appears that the leakage may relate as much to the lack of condensation as to the presence of sealer.

Therefore, lacking evidence of experimental error, the most likely explanation for the surprisingly equal leakage, with or without sealer seen in this study, appears to rest on combining pressure condensation with excellent access. Unfortunately, the factor of only ten specimens in each group probably made differences too small to be of statistical significance. Still, since 30 teeth had sealer and 30 teeth did not, the small number in individual groups does not appear to be the answer for the consistent results seen for this larger area of sealer versus no sealer.

One other possibility needs mentioning. That is, is it possible that 4 hours is too short a time period for the apexes to be in a solution of 50 microcuries per ml of ^{45}Ca? This also does not appear to be the reason since it was shown that in each group the isotope was capable of penetrating to the depth studied (4.8mm within the 4 hours).

Next discussion of the small differences seen in leakage related to the technique used in this study is indicated. In the lateral

condensation and mechanical compaction techniques with and without sealer, it was seen that close to the apex the group with sealer showed a better seal. However, as the distance from the apex increased, the sealing capability appeared about equal.

This then raises the question of why the seal with vertical condensation did not appear to relate well with the level of instrument condensation. It is possible that in vertical condensation the shrinkage of the gutta percha after heating determines the seal rather than the depth of instrument penetration. In fact, with vertical condensation, the group without sealer actually exhibited the better seal. A possible explanation is that with sealer, the heat expands the gutta percha forcing most of the sealer out of the area to be removed by the condensation instruments or into the dentinal tubules. On cooling the gutta percha may pull away from the sealer, or it may pull the sealer away from the dentinal tubules. In either case the seal could be broken. It is possible that without sealer, warming of the gutta percha actually forces the gutta percha rather than the sealer into the dentinal tubules establishing a mechanical bond. Upon cooling, the contraction of the gutta percha may occur more within the mass rather than at the gutta percha-dentin interface leaving a more consistent seal.

Since the compaction technique appears to be a technique where the gutta percha is warmed during obturation, comparable results to vertical condensation might be expected. This did not occur. It is possible that while the compactor does heat the mass of gutta percha, it heats it to a lesser degree. Also, as the instrument backs rapidly out of the

canal and the apical portion of gutta percha cools, it is under constant pressure. Therefore, the shrinkage after final compaction may be less than that which occurs after the technique of vertical condensation. This may allow the gutta percha and sealer to combine their sealing effect more in the manner of lateral condensation than vertical condensation.

SUMMARY AND CONCLUSIONS

Single canal teeth were instrumented and filled "in vitro" using two commonly employed methods of gutta percha obturation with and without sealer. A third technique, employing a recently introduced method of thermomechanical compaction was also utilized. Following obturation, the teeth were soaked in a ^{45}Ca solution and autoradiographs were utilized to evaluate leakage of the various techniques. Statistical analysis of the results indicated there were only minor differences between any of the obturation techniques regardless of whether or not an intra-canal sealer was used.

From the data in this experiment, it appears that the McSpadden (compaction) technique of obturation compares favorably with the lateral and vertical obturation techniques. Again, further research on the ability of the McSpadden technique in more complex canal systems is indicated. This study also appears to confirm that the depth of penetration of the condensing instrument is a significant factor in the final seal.

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Table 1: Number of Specimens Exhibiting Leakage in Each Group: 4 and 17 Hr. Exposure

	Groups	Hours	1.4mm	2.9mm	3.3mm	4.8mm
I.	Compaction	4	8 (80%)	2 (20%)	1 (10%)	1 (10%)
	No Sealer	17	8 (80%)	2 (20%)	1 (10%)	1 (10%)
II.	Compaction	4	4 (40%)	1 (10%)	0	0
	Sealer	17	4 (40%)	2 (20%)	1 (10%)	1 (10%)
III.	Lateral Condensation	4	8 (80%)	3 (30%)	1 (10%)	0
	No Sealer	17	8 (80%)	4 (40%)	2 (20%)	1 (10%)
IV.	Lateral Condensation	4	6 (60%)	1 (10%)	1 (10%)	0
	Sealer	17	8 (80%)	2 (20%)	2 (20%)	1 (10%)
V.	Vertical Condensation	4	4 (40%)	2 (20%)	2 (20%)	0
	No Sealer	17	4 (40%)	2 (20%)	2 (20%)	1 (10%)
VI.	Vertical Condensation	4	6 (60%)	4 (40%)	4 (40%)	0
	Sealer	17	6 (60%)	4 (40%)	4 (40%)	1 (10%)

Table 2: Number of Specimens Showing Leakage at 4 and 17 Hours.

Exposure Time	Leakage Yes	No
4 HR	59	181
17 HR	72	168

df = 1 x^2 = 1.77 NS

Table 3. Number of Specimens Showing Leakage Within Each of the Three Techniques

	LEAKAGE					
	Compaction		Lateral		Vertical	
	Yes	No	Yes	No	Yes	No
No Sealer	12	28	15	25	19	31
Sealer	8	32	13	27	15	25
	df=1 x^2=1.06 p<0.30		df=1 x^2=0.22 p<0.50		df=1 x^2=2.14 p<0.20	

LEGEND

Fig 1 Comparison of 4 and 17 hour exposures. Specimen of same three teeth which had received mechanical compaction fills with sealer.

A. Four-hour exposure at 1.4mm. Heavy radioactivity on outer root surface of all three specimens. Right and left specimens exhibit black dot (radioactivity) in center of unfilled canal space. Center specimen shows extensive leakage around core fill.

B. Seventeen-hour exposure at 1.4mm. No real change from 4-hour specimen.

C. Four-hour exposure at 2.9mm. Again, heavy radioactivity on root surface but no leakage of fills at this level.

D. Seventeen-hour exposures at 2.9mm. Middle and right specimens more detailed than 4-hour exposure with cracks or lateral canals but no actual leakage. Center specimen does show leakage not evident in 4-hr. specimens.

Fig 2 Comparison of leakage of 17-hour exposures of the mechanical compaction technique.

A. No Sealer - 1.4mm level. Leakage of center and left specimens.

B. No Sealer - 2.9mm level. No obturation leakage. Center specimen shows crack or lateral canal.

C. Sealer - 1.4mm level. Leakage of left specimen.

D. Sealer - 2.9mm level. Continued leakage of left specimen.

Fig 3 Comparison of leakage of 17-hour exposure of the lateral condensation technique.

A. No Sealer - 3.3mm level. Leakage of center and left specimens.

B. No Sealer - 4.8mm level. Continued leakage of left specimen.

C. Sealer - 3.3mm level. Leakage of left specimen. (Rare case where center and right specimens had generalized background radiation but did not appear to be leakage).

D. Sealer - 4.8mm level. Continued leakage of left specimen.

Fig 4 Comparison of leakage of 17-hour exposures of the warm vertical condensation technique.

A. No Sealer - 1.4mm level. Leakage of left specimen.

B. No Sealer - 2.9mm level. Continued leakage of left specimen.

C. Sealer - 1.4mm level. Leakage of left and right specimens.

D. Sealer - 2.9mm level. Continued leakage of left specimen.

FIGURE 1A

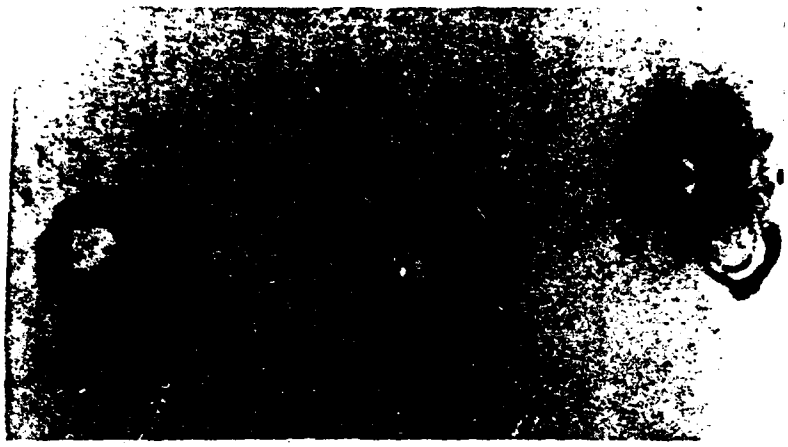


FIGURE 1B

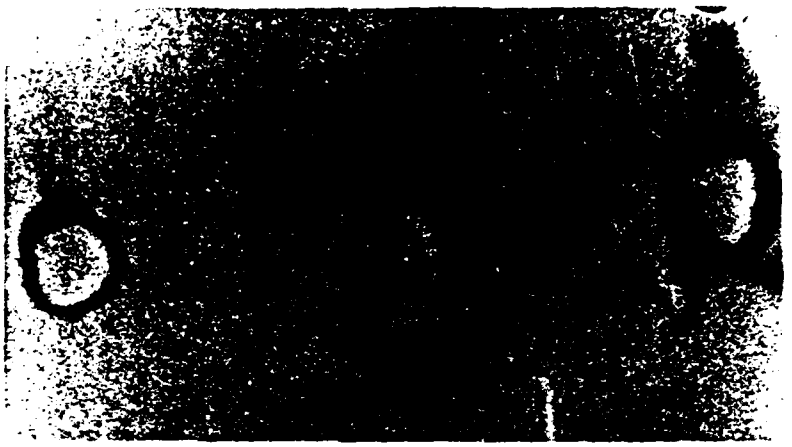


FIGURE 1C

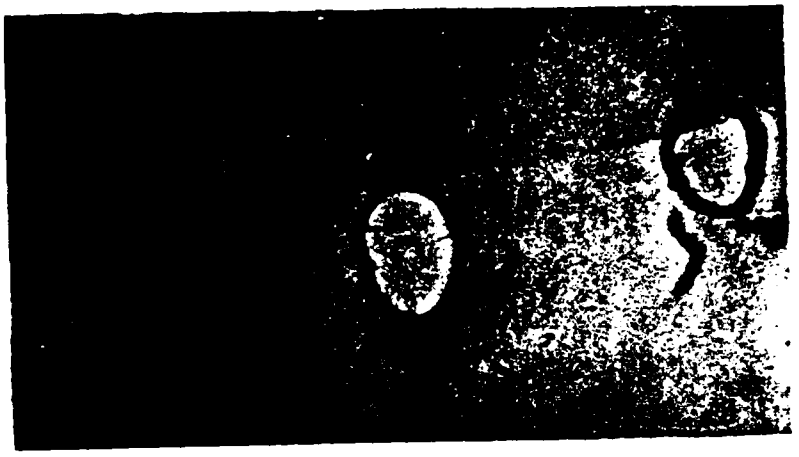


FIGURE 1D

FIGURE 2A

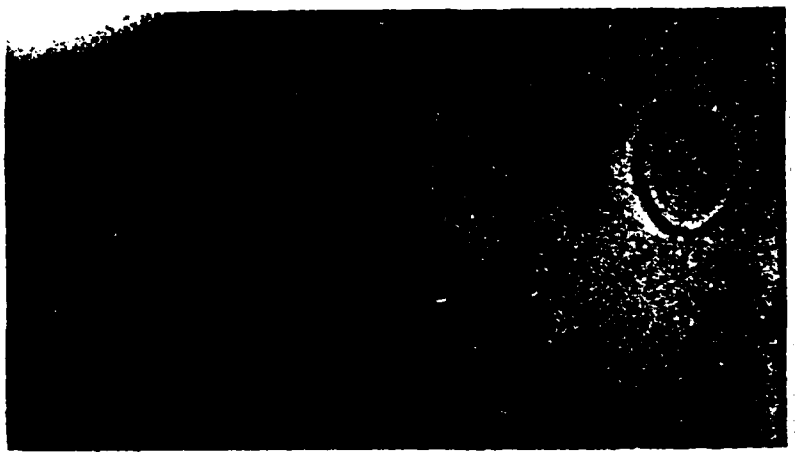


FIGURE 2B

Figure 2C

Figure 2D

FIGURE 3A

Figure 3B

FIGURE 3C

Figure 3D

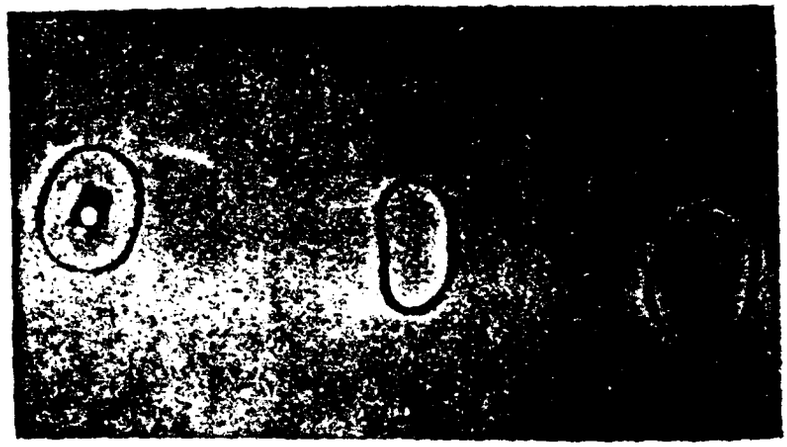
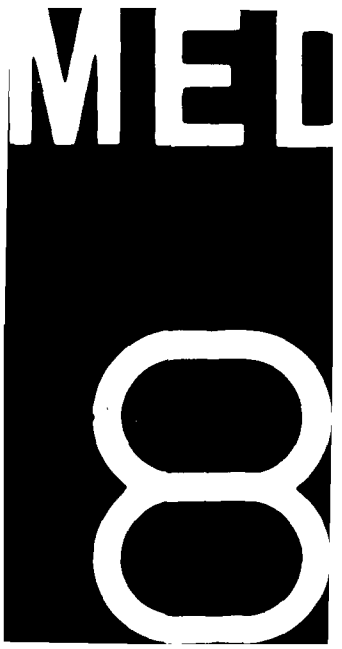


FIGURE 4A

FIGURE 4B

FIGURE 4C

FIGURE 4D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